# The Weather and Circulation of September 1962

## Another Cool Month

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### 1. INTRODUCTION

September 1962 was a very cool month over most of the United States continuing the summer pattern of abnormally cool weather over much of the country. Warm weather was confined to parts of the Gulf region and the Far West. It was wetter than normal from the southern Rockies across the Plains to the Tennessee Valley. Generous rains alleviated the extreme drought conditions which prevailed at the end of August in southern Missouri, parts of Louisiana and eastern Texas, the Tennessee Valley, and eastern Ohio and Pennsylvania. These rains were associated with a confluent pattern of westerlies displaced south of normal in the average monthly circulation over the United States, and considerable blocking over southern Canada.

September 1962 showed a marked contrast over North America and the Pacific to its counterpart in 1961 [1] when a strong planetary ridge occurred in the Gulf of Alaska with a deep trough over the Rockies. The opposite phase of the planetary waves this September brought much warmer temperatures to the Far West and cooler temperature to the East, as well as reversals in the precipitation regime.

The month was notable for a total absence of hurricanes in the Atlantic and Caribbean, and only about two days of tropical activity of "storm" intensity.

Other notable events within the United States were the early snowfall in parts of Montana and Wyoming on the 7th and 8th, the near-record rainfalls in parts of the Colorado, Arkansas, and Tennessee Valleys, excessive rains in parts of Florida on the 20th and 21st, and a "northeaster" which produced more than half the nonth's rainfall over much of the Northeast on the 27th and 28th with gale force winds in some sections.

Outside the United States a disastrous flood struck Barcelona Province, Spain, on the 26th in that country's worst natural disaster of modern times. Hundreds died, and many were injured or homeless as a result of heavy rains reportedly accompanied by hurricane-force winds. The associated synoptic-scale disturbance at the surface however, was only of average intensity.

### 2. THE PLANETARY CIRCULATION

The average circulation at 700 mb. in September 1962 (fig. 1) was one of relatively flat westerlies in middle and high latitudes, associated with above normal heights in the three regions of normal planetary troughs in September [2]; the Bering Sea and Central Pacific, the Labrador region, and the Upper Yenisei Basin in Siberia. At the same time the planetary ridges normally present in the Yukon and Scandinavian regions were weaker than normal. A deep polar Low near northern Greenland, together with above normal heights to the south, produced strong polar westerlies and a planetary wave number of 2 in the Arctic. The axis of strongest westerlies was about 5° south of normal from the Great Lakes across the Atlantic, and north of normal by as much as 8° of latitude in the Pacific.

This circulation had many features in common with that of the summer [3], including troughs near both coasts of North America, and blocking in the Central Pacific and Labrador.

The monthly circulation was composed of two sharply differing regimes (fig. 2). In the first part of the month (fig. 2A) a strong ridge in the eastern Pacific helped maintain a deep trough in the middle of North America. Confluence was an important characteristic of the flow in the United States and blocking was strong in the Davis Strait. In the western Pacific two troughs, unusually close together for a planetary scale circulation, extended southward from the Bering Sea and Manchuria.

During the last part of the month (fig. 2B), deepening and progression of the Manchurian trough was accompanied by strong trough development north of Hawaii as the sheared trough previously in the Bering Sea accelerated eastward, probably in response to the short initial wavelength (fig. 2A). The reamalgamation of the sheared trough at high latitudes with the stationary low-latitude trough near Hawaii was accompanied by strong amplification of a full-latitude mean trough north of Hawaii (fig. 2B). This was accommodated downstream by the relocation of the North American trough along the east coast, and the mid-Atlantic trough near the coast of Spain and North Africa. Meanwhile, the earlier blocking over the Davis Strait became relocated over western Canada.

### 3. CIRCULATION CHANGES

The changes in height at 700 mb. from August to September 1962 in excess of the normal monthly changes

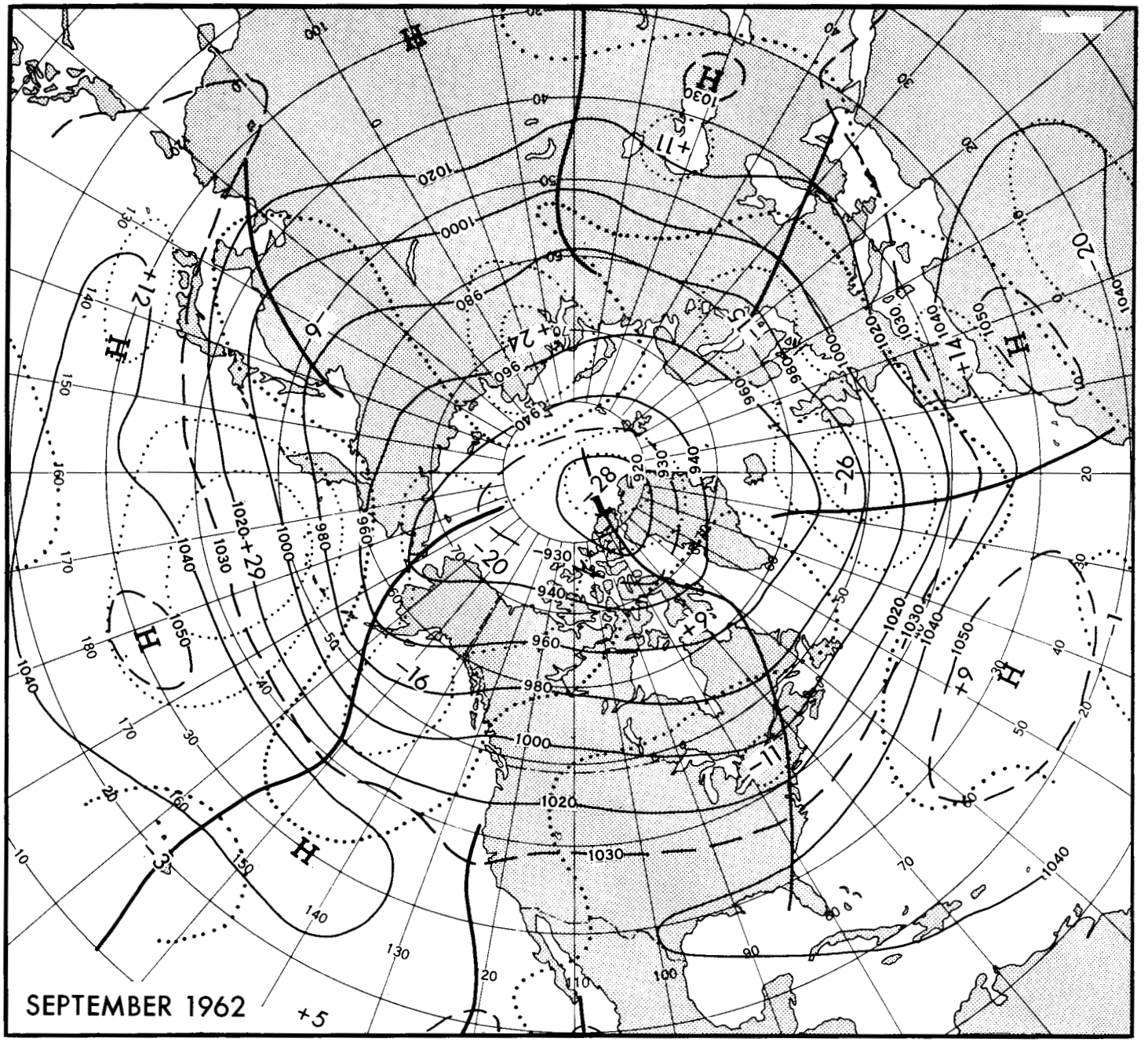


FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for September 1962 Although pattern was similar to the normal, the westerlies were displaced southward in the United States.

are shown in figure 3. The largest changes in the hemisphere were the increasing heights centered in the northwestern Pacific. That the latter were important in reshaping the circulation to the east, including North America, may be inferred from the average height anomaly relationships given by Martin [4]. These show, for example, that a positive height anomaly centered near the location of the large height rise center in the western Pacific in figure 3 tends to be associated with negative departures over most of the United States except in the Northwest and Southeast, where heights tend to be above normal.

The circulation changes at 700 mb. between the first and last halves of September are shown in figure 4. Marked deepening occurred in eastern Siberia, north of Hawaii, and in eastern North America. The height rises in western North America, which are dynamically associated with the deepening in the eastern Pacific, may also be viewed as a retrogression of the earlier blocking in eastern North America. Similarly the height rises near

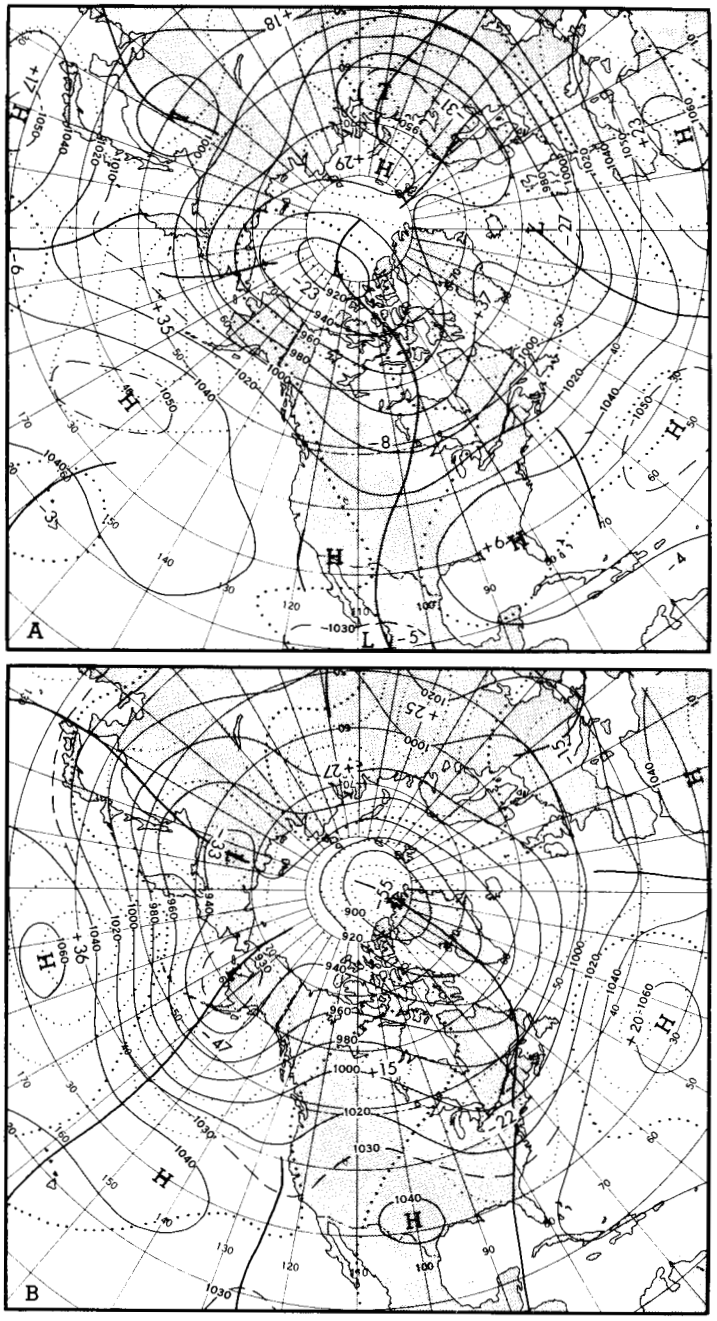


FIGURE 2.—Average 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet for (A) early September and (B) late September 1962. The marked change in regime was characterized by development of a strong eastern Pacific trough and relocation of the planetary trough near the east coast of North America.

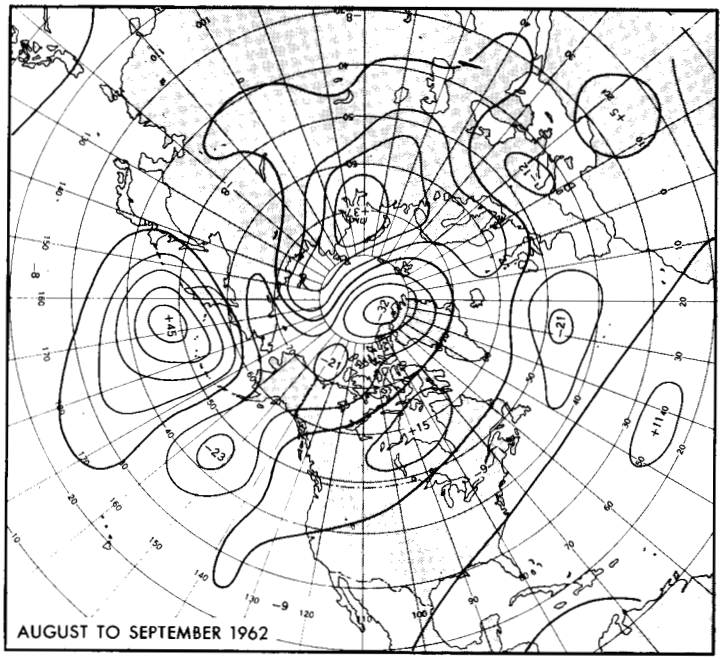


FIGURE 3.—Change in 700-mb. height departures from normal (tens of feet), from August to September 1962. Rises over Canada and falls over the United States suggest blocking and southward-displaced westerlies.

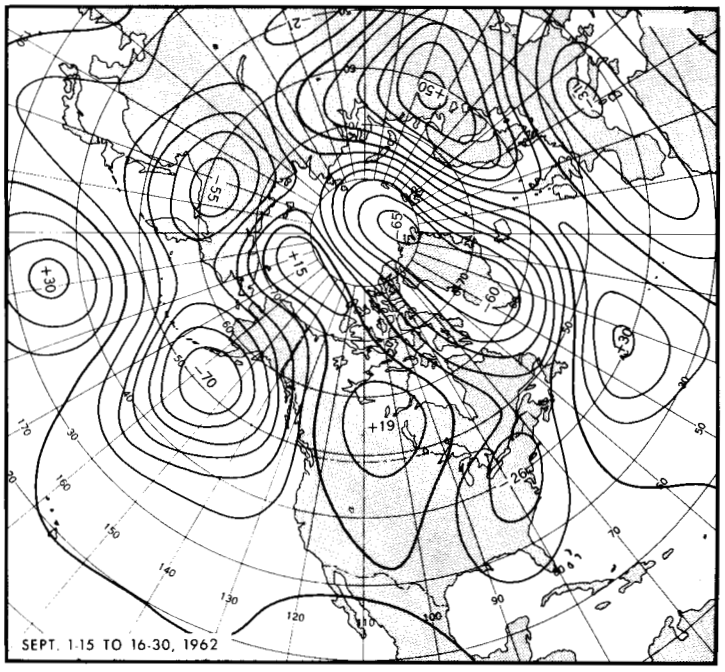


FIGURE 4.—Change in 700-mb. height between first and last half of September 1962 (tens of feet). Deepening in the eastern Pacific and eastern North America featured the change in regime.

Scandinavia may be viewed as a retrogression of the Eurasian block.

## 4. INTRA-MONTHLY EVOLUTION

### SEPTEMBER 1–5

A strong mean ridge in the Gulf of Alaska (fig. 5A) spawned a vigorous surface High in the Yukon on the 1st which moved to the Mississippi Valley on the 5th (chart VIII of [5]) bringing unseasonably cool weather to the central United States. Temperatures for the period averaged as much as 11° F. below normal and daily values ranged to 22° F. below normal in Kansas on the 5th.

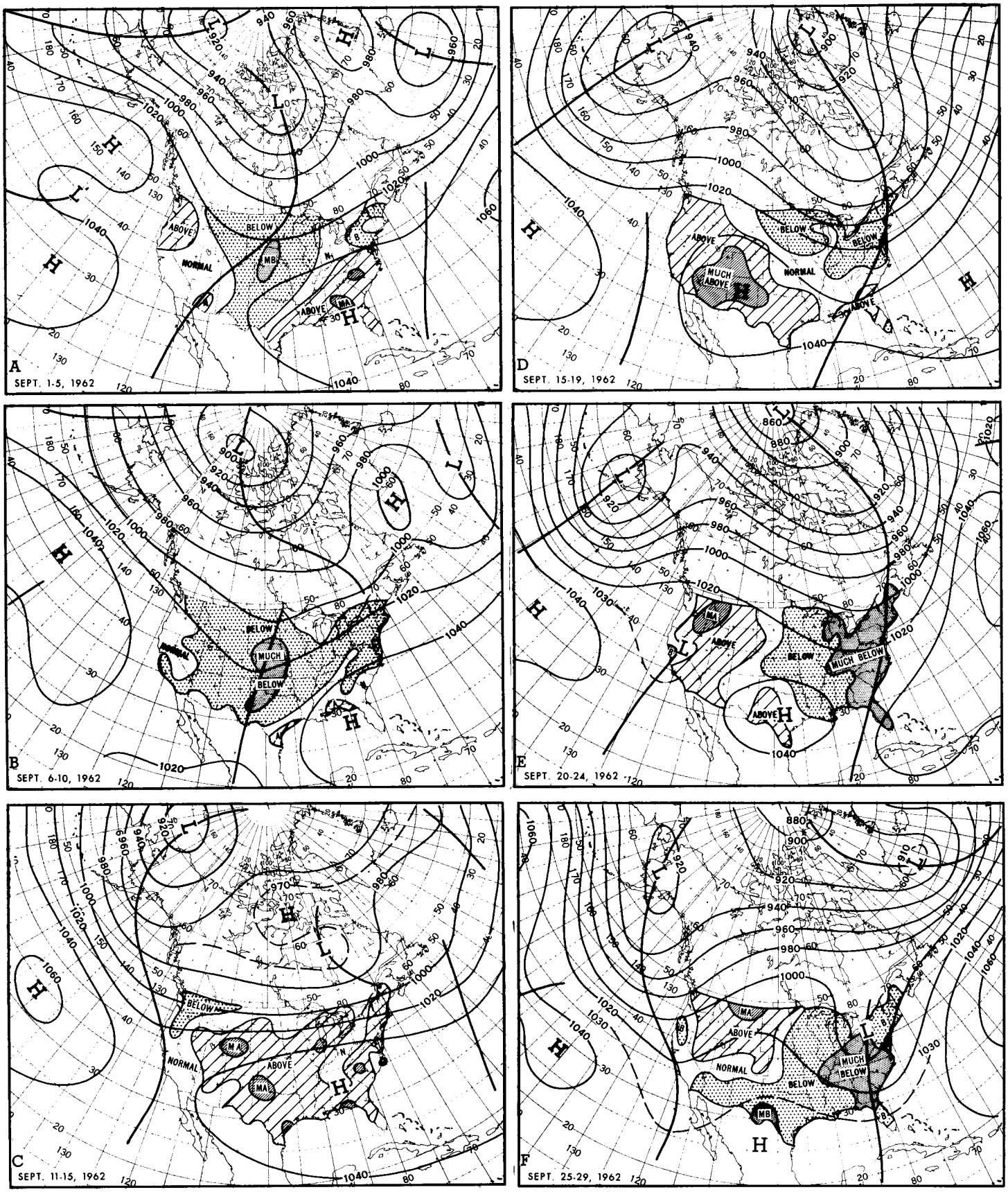


FIGURE 5.—Mean 700-mb. contours (tens of feet) and observed temperature anomaly classes (above normal hatched, below normal stippled) for consecutive 5-day periods in September 1962. Early in the month the strong ridge in the eastern Pacific maintained a deep cold trough in central North America, whereas later in the month trough development in the eastern Pacific was accompanied by relocation of the cold North American trough near the east coast.

Record minima occurred on the 4th and 5th from the Rockies to the Mississippi Valley as far south as Kansas and Missouri.

Heavy precipitation, in some places 3 inches or more, occurred over large areas east of the deep trough near the Continental Divide.

SEPTEMBER 6–10

Although the ridge in the Gulf of Alaska was somewhat weaker in this period (fig. 5B), the westerlies there were still considerably north of normal, favoring still another surface High in the Yukon on the 6th, exactly 5 days after its predecessor. This set the stage for a repetition of the previous 5-day evolution, as this second Yukon High also moved into the Mississippi Valley on the 10th. Again temperatures averaged as much as 11° F. below normal in the central and southern Plains and daily values were as much as 28° F. below normal in Montana on the 8th. Many record minimum temperatures occurred north and east of the central Mississippi Valley during the first outbreak of polar air on the 6th and 7th, and in the central Plains and northern Rockies with the second outbreak from the 8th to the 10th.

Heavy precipitation again fell throughout most central sections, including a heavy early season snowfall on the 7th and 8th in parts of Montana and Wyoming, associated with the deep mean trough in the middle of the country. Rainfall of over 3 inches again fell in parts of Texas, as well as the Southeast, associated with overrunning of the cold air which penetrated those areas. West of the Rockies mostly dry conditions continued.

SEPTEMBER 11–15

This period started out as a repetition of the previous two 5-day cycles with still another thrust of cool air into the northern Rockies on the 11th and 12th. Missing this time, however, were the strong Yukon Highs of the two previous occasions, owing to the deep trough which had developed in the Gulf of Alaska (fig. 5C), while the previously strong ridge there retrograded to the Bering Sea. Nevertheless a surface High again appeared over Montana on the 13th although weaker than its predecessors of the 3d and 8th. Meanwhile, a strong warming trend set in from the southern Plains to the Great Lakes where daily temperatures rose to 16° F. above normal in Illinois on the 13th. This warming accompanied filling and disappearance of the trough previously in mid-continent, probably in response to the proximity of the new mean trough near the west coast. The resulting regime of flat westerlies, farther north than normal over the United States, interrupted the earlier cycle of Highs plunging into the Mississippi Valley. In addition, the upper-level anticyclone retrograded from the Southeast to the southern Rockies during the period. This marked change in the circulation brought warmer-than-normal temperatures to most of the country, ranging to 10° F. above normal in the central Rockies and southern Plains, in contrast to the cool weather over nearly the entire country 5 days earlier.

The northward shift in the westerlies also ended precipitation over the northern and central Plains. However, heavy to locally excessive rains, associated with frontal disturbances, fell in parts of the central Mississippi and Tennessee Valleys when, for example, within 4 hours, 5.03 inches fell at Nashville, Tenn., on the 13th, a new record, and 3.84 inches fell at Springfield, Mo., on the 14th.

SEPTEMBER 15–19

During this time the upper-level anticyclone over the southern Rockies was reflected in unseasonable warmth in the West, averaging as much as 10° F. above normal in the Four Corners region. Retrogression and further deepening of the Gulf of Alaska trough was accompanied by ridge amplification over western Canada (fig. 5D), about 30° longitude east of the ridge in the Gulf of Alaska earlier in the month (fig. 5A). This shifted the origin of polar outbreaks from the earlier location in the Yukon to near Lake Winnipeg, where a strong High developed on the 18th. The cold air outbreak associated with that High lowered temperatures in the upper Mississippi Valley to 15° F. below normal on the 19th. At that time the surface High was centered over southern Lake Winnipeg, making it the fourth High of a 5-day cycle in the vicinity of North Dakota, the previous three having occurred on the 4th, 9th, and 14th.

Precipitation at this time was heavy from the central Plains across the lower Mississippi Valley to the Carolinas, where more than 4 inches fell in connection with frontal disturbances early in the period.

SEPTEMBER 20–24

Cold air spread throughout the eastern half of the country during this period due to further strengthening of the northerly flow between the intensified Canadian ridge and the deep trough near the east coast (fig. 5E). Temperatures averaged as much as 15° F. below normal at Pittsburgh, Pa., while daily values were as much as 19° F. below normal on the 20th and 21st, moderating to 10° F. below normal on the 24th. Many record minimum temperatures occurred from the Ohio Valley across the Northeast on the 20th to 22d as a High moved through the Middle Atlantic States on the 21st. Another followed in rapid succession plunging from Victoria Is. on the 20th to Lake Winnipeg on the 21st and then turned eastward across southern Canada as a deepening storm traveled up the Atlantic coast from the 23d to the 25th in its wake. On the 24th another High appeared near the North Dakota-Manitoba border, the fifth such High in that area at consecutive 5-day intervals.

Temperatures again remained warm from the Rockies westward, averaging as much as 9° F. above normal at Spokane, Wash.

Precipitation was relatively light in the East except for Florida where very heavy rains fell in some places on the 20th and 21st when a sharp trough aloft overlay a strong

frontal boundary at the surface; Fort Myers, for example, received 9.34 inches of rain in 24 hours, the greatest on record for September. The eastern Rockies and central Plains, dominated by confluent flow east of the trough over California also received heavy precipitation during the passage of a cyclonic vortex aloft which drifted slowly from the California-Oregon coast on the 20th to Minnesota on the 24th.

SEPTEMBER 25–29

In the last few days of the month the trough from the Pole southward along the east coast of the United States fractured. The northern part reamalgamated with the eastern Atlantic trough (fig. 5F) accompanied by intense deepening of a cyclonic vortex south of Iceland which at the surface attained a minimum pressure of 950 mb., and covered a large part of the North Atlantic.

In North America the period commenced with a surface High center near Iowa on the 25th, the fifth High with a periodicity of 5 days during the month. As this High weakened, a new one intensified near Hudson Bay and moved eastward across Labrador in blocking fashion north of the track of a similar High 5 days earlier. This reflected the relocation near Hudson Bay (fig. 5F) of the mean ridge which was previously over western Canada. An associated cold air outbreak spread southward over the eastern half of the United States and the southern Plains and Rockies resulting in average temperatures as much as 10° F. below normal in the Ohio and Tennessee Valleys.

The mean trough in the eastern United States spawned a deep, slowly moving, cutoff Low in the lower Great Lakes Region at this time. This was reflected at the surface in a developing coastal storm similar to another 4 days earlier. However, this Low was blocked by the strong High over Labrador, and the coastal storm filled on the 28th, leaving a cold surface Low under the upper vortex over Pennsylvania and New York.

This storm system produced over half of the month's precipitation in parts of the Northeast and up to 40 hours of continuous rain in some places. Due to the strong pressure gradients between the storm and the blocking High to the north over Labrador, damaging northeasterly gales occurred in parts of the Northeast especially along the New England coast.

During this period precipitation was also heavy in the Far West, due to a deep mean trough from the Gulf of Alaska southeastward along the west coast. Rains were also heavy throughout the southern United States because of the southward displacement of the jet and a strong front across that region on the 25th and 26th.

## 5. TEMPERATURE

Temperatures in the United States averaged cooler than normal this September except in the Far West and parts of the Gulf States (fig. 6). The cool regions were associated with mostly below normal heights (westerlies south of normal) on the average (fig. 1), while warm regions in the Far West were associated with westerlies north of normal.

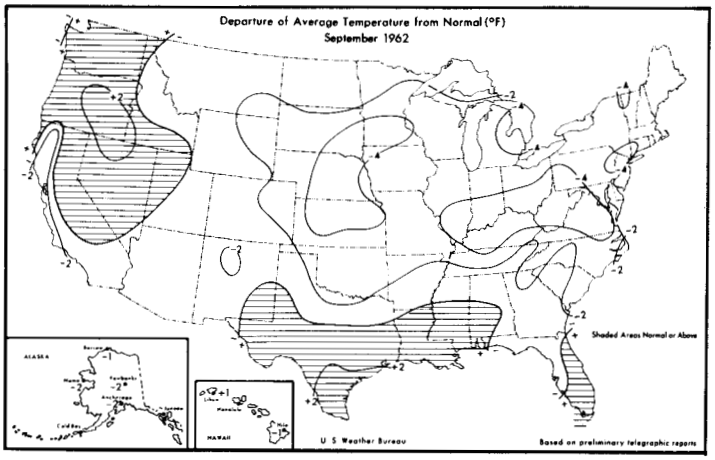


FIGURE 6.—Departure of average surface temperature from normal (°F.) for September 1962. Unseasonably cool weather occurred over a large part of the country. (From [7].)

In comparison with the preceding August, temperatures were cooler relative to normal as much as two classes (out of 5) in 65 percent of the country from the southern Rockies eastward and northeastward, associated with lower heights at 700 mb. (fig. 3). In the northern Rockies and westward, temperatures were warmer relative to normal than in August by as much as three classes associated with a northward drift of the westerlies. Temperature persistence, however, was close to the 1942–1957 August to September average of 70 percent [6] since 68 percent of the country failed to change by more than one class.

Despite the widespread coolness this September, few new records were set. A notable exception, was Grand Island, Nebr., which reported a record average temperature of 59° F., or 7.7° F. below normal. Philadelphia, Pa., also reported its lowest September average temperature, 63.1° F. since 1875. It was, however, one of the coldest Septembers on record at San Francisco, Calif., Minneapolis, Minn., Youngstown, Ohio, and Wilmington, Del. Many new daily minimum temperature records were established during the numerous cold outbreaks discussed in the previous section.

Few maximum temperatures were noteworthy, although Phoenix, Ariz., reported new maximum temperature records on four successive days, from the 17th to the 20th when the upper-level anticyclone was centered almost directly over that region.

## 6. PRECIPITATION

The principal zone of heavy precipitation this September extended from the southern Rockies across the Plains to the Tennessee and Ohio Valleys (fig. 7). This region was characterized by a confluence of the westerlies in the average flow (fig. 1), together with a mean frontal zone from southeastern New Mexico eastward across the Gulf States as indicated by the contrast in observed tempera-

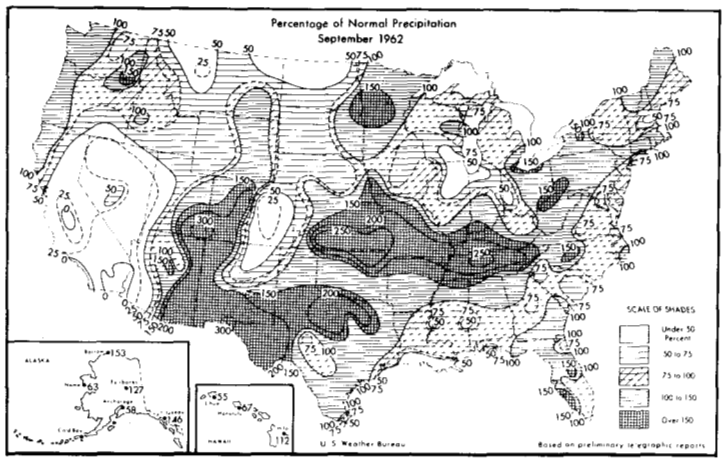


FIGURE 7.—Percentage of normal precipitation for September 1962. (From [7].)

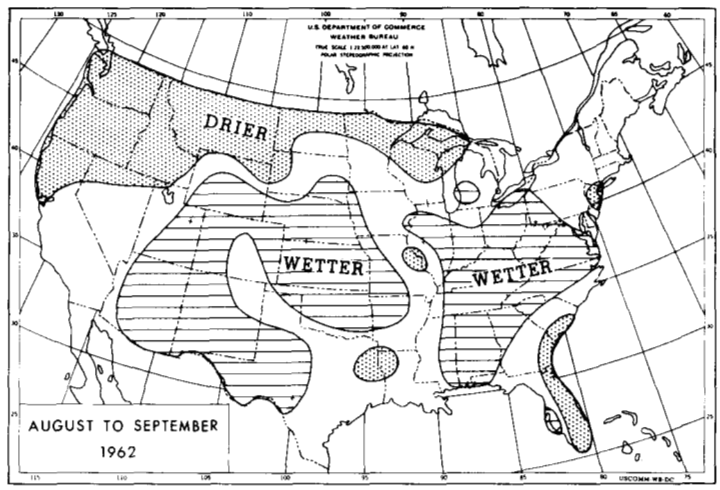


FIGURE 8.—Changes in precipitation categories from August to September 1962. Hatched areas received heavier amounts, and stippled areas lighter amounts by one to two classes. The heavier amounts occurred in the confluent region where the westerlies were south of normal.

ture anomalies in figure 6. Precipitation was also locally heavy along the Pacific Northwest coast associated with the eastern Pacific trough, and locally excessive in parts of Florida and the Georgia coast associated with the mean trough there (fig. 1).

In contrast to August of this year, precipitation was heavier from the eastern Rockies to the east coast (fig. 8) in the zone of negative height differences shown in figure 3, which reflects a more southerly location of the westerlies relative to normal this month. The drier conditions in the North and Northwest on the other hand were associated with positive height differences reflecting the more northerly location of the westerlies. The composite effect of the height rises in Canada and falls in the southwestern United States was to impart a more confluent character to the September flow (fig. 1) and thus favor greater precipitation in the drought areas of the central Mississippi and Tennessee Valleys and the Northeast. However, drought was still near-critical by month's end in parts of Texas, Pennsylvania, Maryland, Mississippi, and north-central Montana.

## 7. TROPICAL LOWS

In the Atlantic, tropical cyclone activity was considerably less than normal in September 1962, since only two tropical Lows were observed and neither approached hurricane intensity during the calendar month. Of these Celia was judged to be of "storm" intensity for only about two days. It was first observed about 700 miles east of the Leeward Islands on the 13th and subsequently diminished in intensity and curved northward and disappeared east of Bermuda on the 21st.

Tropical depression Daisy was detected in the same area as Celia on the 28th. By month's end it was near the Virgin Islands curving northward. During October Daisy increased to hurricane intensity and traveled northward to the Maritime Provinces.

In the eastern Pacific there were two storms near the west coast of Baja California, Bernice on September 2–5, and Claudia on September 20–23.

Although the average circulation and its departure from normal in the eastern Atlantic for September (fig. 1) were quite similar to September 1961 when three hurricanes developed [2], none developed this month in that part of the ocean.

In the western Atlantic and Caribbean areas the scarcity of tropical Lows this year was associated with westerlies south of normal over the United States and the Atlantic, accompanying blocking in Canada and Greenland. In these circumstances, subtropical easterlies, which are believed to be favorable for vortex motion, remained underdeveloped. However late in the month, a much stronger than normal High developed in the central Atlantic (fig. 2B) accompanied by stronger than normal easterlies to the south. It was in this regime that Daisy formed, later developing into a hurricane during October.

Although tropical activity was less than normal in the Atlantic, there have been many similar Septembers in recent decades. According to [7], in 1890 and 1930 none was observed, and in 1895, 1914, 1925, and 1939 only one Low of "storm" intensity was observed.

In the western Pacific, tropical activity was about normal for September with five Lows observed. Three of these, Amy, Carla, and Dinah reached typhoon intensity. Amy moved westward across northern Formosa into China in the first few days of the month. Dinah formed in the Philippine Sea near month's end and moved westward across southern Formosa in early October.

Tropical storm Babe developed in the South China Sea on the 14th, moving inland over Viet Nam two days

later. Typhoon Carla formed in the same area on the 19th and crossed the coast of Viet Nam on the 21st.

The westward tracks of all the western Pacific storms were probably influenced by the stronger than normal ridge from eastern China to southern Japan which resulted in stronger than normal easterlies over the Philippine and South China Seas.

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7. G. W. Cry, W. H. Haggard, and H. S. White, "North Atlantic Tropical Cyclones," U.S. Weather Bureau, *Technical Paper* No. 36, 1959.
8. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIX, No. 41, Oct. 8, 1962.

## CORRECTION

November 1962 issue, p. 462: In col. 1, 15th line from bottom should read ". . . therefore the first quantity of equation (5) must remain . . .", instead of "equation (2)."